Scoping calculations for the near-field evolution in a geological repository for high-level radioactive waste in Boom Clay in the Netherlands

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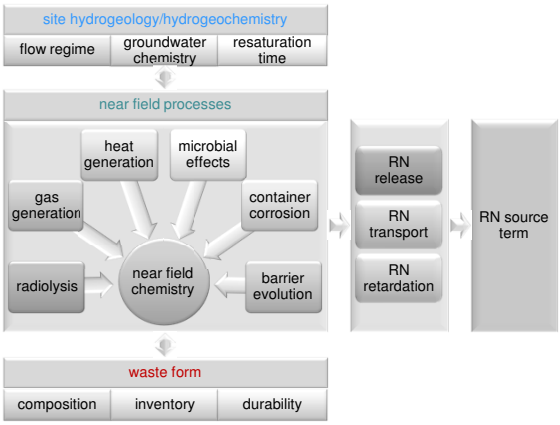
Background: A central objective of the OPERA research programme, recently initiated by the Dutch radioactive waste management organisation COVRA, is the development of an initial conditional safety case for a generic repository in the Tertiary Boom Clay in the Netherlands. The generic disposal concept for high-level radioactive waste (HLW) in Boom Clay pursued in this context is based on the Belgian supercontainer concept[1]. In this concept, the engineered barrier system (EBS) makes extensive use of cementitious materials as buffer within the waste container, as backfilling grout, and in the construction material for the disposal gallery linings. Thus a highly-alkaline near-field will develop post closure.

Objectives: Evaluation of the corrosion behaviour of and the radionuclide release from vitrified HLW and spent research reactor fuel in a generic repository in Boom Clay in the Netherlands.

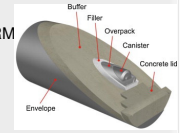
Focal points
- evolution of the near-field
- wasteform evolution and radionuclide release
- radionuclide migration in the near-field
- radionuclide source terms

➢ coherent picture of HLW performance
➢ support of post closure safety assessments



Generic OPERA disposal concept

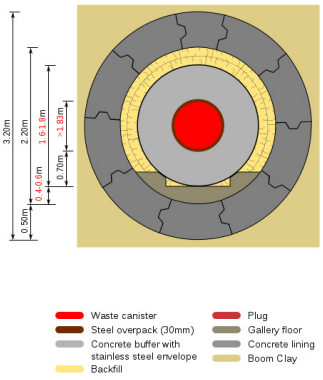
- Host rock formation:
  - Rupel Clay member ("Boom Clay")
  - unindurated, plastic marine clay (lower Oligocene)
- Repository concept:
  - co-disposal HLW/LILW/NORM
  - "Supercontainer" concept for HLW
  - cementitious backfill



- High-level wastes (*c.* 1.000 m³):
  - HLW glass (R7T7, MW)
  - research reactor spent fuel
  - non-heat generating wastes (hulls, ends)
  - targets from Mo-99 production
- LILW & NORM (*c.* 70.000 m³)

Cementitious materials in the EBS (Reference Scenario)

Disposal gallery (schematic cross section)

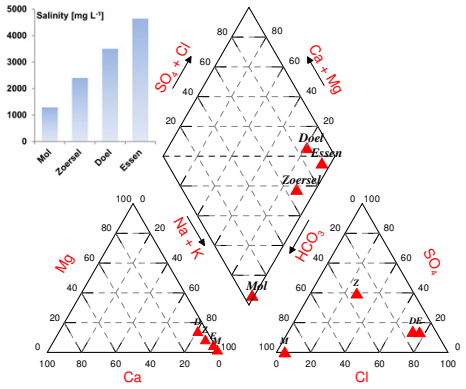


Supercontainer buffer[4]	
CEM I	350 kg m^{-3}
limestone aggregate	1.950 kg m^{-3}
water	150 kg m^{-3}
w/c-ratio	0.43

Backfill	
CEM I	450 kg m^{-3}
limestone flour hydrated lime	495 kg m^{-3} 170 kg m^{-3}
Water	615 kg m^{-3}
w/c-ratio	1.37

Gallery lining[5]	
CEM I PFA	430 kg m^{-3} 150 kg m^{-3}
aggregate	1.600 kg m^{-3}
water	180 kg m^{-3}
w/c-ratio	0.32

Composition of Boom Clay pore waters[2-3]



→ Data from boreholes in Northern Belgium

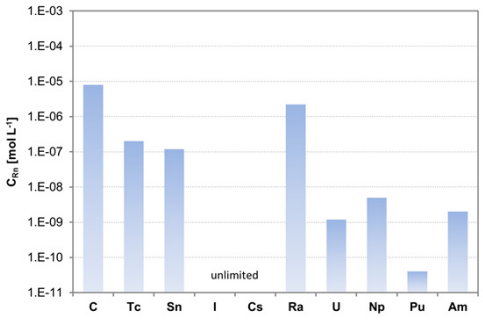
Evolution of pore water composition in the buffer (Scenario: lower salinity Boom Clay pore water)

		YCPW_LS	ECPW_LS
pH	[-]	13.4	12.5
E_H	[mV]	~ -780	~ -720
Na	[mmol L^{-1}]	130	14
K	[mmol L^{-1}]	320	0.3
Ca	[mmol L^{-1}]	0.8	16
Mg	[mmol L^{-1}]	1E-05	1E-04
Si	[mmol L^{-1}]	0.05	0.01
CO_3^{-2}	[mmol L^{-1}]	0.2	8E-03
SO_4^{-2}	[mmol L^{-1}]	1.9	0.2
Cl^-	[mmol L^{-1}]	0.2	0.2

→ Pore water composition in the concrete buffer derived from scoping calculations for lower salinity Boom Clay pore water:
- YCPW: young concrete pore water (n·1.000 years)
- ECPW: evolved concrete pore water (n·10.000 years)

→ assumed redox control by magnetite and $Fe(OH)_2$ in the presence of metallic iron

Radionuclide solubility in evolved concrete pore water



→ Calculated radionuclide solubility in the evolved concrete pore water (scenario lower salinity Boom Clay pore water) using the NAGRA/PSI database

Outlook

- Scoping calculations indicate high-pH conditions in the concrete buffer for several ten thousand years.
- Concentrations of corrosive species (e.g. Cl) at the overpack interface depend on the composition of the Boom Clay pore water.
- More realistic assessments of the near-field evolution and radionuclide behaviour can be derived from reactive transport simulations considering
  - more realistic assumptions regarding the flow regime,
  - kinetic mineral reactions,
  - solid solution formation, and
  - the evolution of the pore space due to dissolution/ precipitation reactions.

References:
[1] E. Verhoef *et al.* 2011, Report OPERA-PG-COV008. [2] M. De Craen *et al.* 2004, Report SCK•CEN-BLG-990. [3] M. De Craen *et al.* 2006, Report SCK•CEN-ER-19.
[4] J.J.P. Bel *et al.* 2006, Mater. Res. Soc. Symp. Proc. Vol. 932, 10 p. [5] ONDRAF/NIRAS 2008, Report NIROND-TR 2007-07E.

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